Evaluation of the microbiological contamination of air in a company designed to obtain wooden packaging and sticks used in the food industry

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Abstract This paper aims to analyze the microbiological load of the air from a wood processing enterprise from the log phase resulted in forest harvesting until the obtained finished products –used for food packaging and sticks. The microbiological parameters determined, in accordance with the law, verifies the presence of colony forming units, total coliforms, coagulase positive Staphylococcus, fecal streptococci respectively β hemolytic streptococci and fungi. The evaluation was conducted monthly in 2013, in two halls - production and finished product selection. The results show the dependence to environmental factors of the microbiological load – temperature, humidity, aswell as other factors – the production process and the proper cleaning processes.

Sanitation of food depends largely on the hygienic conditions in which they are produced, transported and marketed. To this end microbiological control of air is carried out in the workspace and storage. [1] The packages obtained, used in food industry and come into direct contact with the prepared food which is ready to eat, must comply with microbiological standards.

It is therefore very important to remove any contamination sources and the workplace used to obtain food packaging from timber processing must be controled in microbiological terms and requires conformity with the laws in force.

Although the microbiological load of the air is considerable, the atmosphere does not have a specific microflora. [2] Aeromicroflora consists of germs derived from soil, water, human waste, animal, and if you analyze it from woodworking aswell. [2] This being the reason why the microbial load of the atmosphere in a process chamber is high and the microbiological spectrum is various. Some are saprophytic microorganisms present in the air, but there may be pathogenic microorganisms aswell. Although air does not ensure optimal conditions for long survival of microorganisms that inhabit it, sporulated bacteria and fungi can withstand time and can be deposited on various substrates, and brought under optimal conditions, they can germinate. So if aeromicroflora of production facilities analyzed presents a mycological load greater than permitted by the laws - Ordinal MS 976/1998 - spores can settle on finished products, and if the preservation will be long and the humidity high, there is a risk that fungi colonies appear on the surface and in the depth of the sticks, which can determine damage to the sticks and withdrawal of the products from consumption. [3]

Key words wood, UFC, coliforms, staphylococci, streptococci, fungi

Materials and Methods

Given the diversity of contaminating micro-organisms, for each one of them there were used, in cultivational purposes, specific culture media, precast in Petri dishes with the diameter of 10 cm, from the firm Biometrix in Timisoara. Table 1 presents the culture media used for each of the germs that we want to discern, from the atmosphere of the production premises.
Koch method was used for harvesting by sedimentation. [1] This method consists in the opening and exposure of the Petri dishes with the precast culture media in the rooms where the realisation of microbiological determinations are desired, for a period of 5 minutes, after which the plates are closed and placed in the thermostat where they will be stored at optimum temperatures and corresponding period for each germ. In Table 2 the temperature conditions and time periods that ensure the optimal development of the microorganisms are presented.

**Table 1**

<table>
<thead>
<tr>
<th>Nr. crt.</th>
<th>Microbiological parameters</th>
<th>Culture media</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Colony forming units (UFC)</td>
<td>Plate Count Agar (PCA)</td>
</tr>
<tr>
<td>2.</td>
<td>Total coliforms (TC)</td>
<td>Briliance E. coli/Coliform agar</td>
</tr>
<tr>
<td>3.</td>
<td>Staphylococcus coagulase positive (SCP)</td>
<td>Mannitol salt agar (MSA)</td>
</tr>
<tr>
<td>4.</td>
<td>Streptococcus faecalis (SF)</td>
<td>Bile esculine azide agar (BEA)</td>
</tr>
<tr>
<td>5.</td>
<td>Beta hemolytic streptococcus (BHS)</td>
<td>Blood agar</td>
</tr>
<tr>
<td>6.</td>
<td>Fungi (F)</td>
<td>Sabouraud chloramphenicol, gentamicine agar</td>
</tr>
</tbody>
</table>

In the case of bacteria if after 24 hours there is no development of specific colonies on the Petri dishes, they are stored in the thermostat for another 24 hours and the results are expressed after those 48 hours. In the case of fungi, the dishes are stored in optimal temperature conditions up to 5 days. The concentration of germs/m$^3$ of air is determined applying Omelianski's formula. [1]

**Table 2**

<table>
<thead>
<tr>
<th>Nr. crt.</th>
<th>Microbiological parameters</th>
<th>Optimum temperature for growth of germs ($^\circ$C)</th>
<th>Period of incubation (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Colony forming units (UFC)</td>
<td>37</td>
<td>1-2</td>
</tr>
<tr>
<td>2.</td>
<td>Total coliforms (TC)</td>
<td>42</td>
<td>1-2</td>
</tr>
<tr>
<td>3.</td>
<td>Staphylococcus coagulase positive (SCP)</td>
<td>37</td>
<td>1-2</td>
</tr>
<tr>
<td>4.</td>
<td>Streptococcus faecalis (SF)</td>
<td>37</td>
<td>1-2</td>
</tr>
<tr>
<td>5.</td>
<td>Beta hemolytic streptococcus (BHS)</td>
<td>37</td>
<td>1-2</td>
</tr>
<tr>
<td>6.</td>
<td>Fungi (F)</td>
<td>30</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Observing table 3, we observe that the legislation doesn’t provide limit values for all the parameters investigated by our study, referring only to the colony forming units, beta hemolytic streptococcus and fungi.

**Results and Discussions**

Determination of microbiological parameters was conducted monthly throughout 2013. In the company there are two large halls - the production, where wood processing is done and the packaging where finished products are packaged and stored. In the production hall, because of the technological process the atmosphere presents a higher grade of contamination, even though the hall is equipped with huge fans meant to absorb the existing powders. Legislation permits certain limits to these parameters and their values are listed in Table 3.

**Table 3**

<table>
<thead>
<tr>
<th>Nr. crt.</th>
<th>Analysed product</th>
<th>UFC $/m^3$</th>
<th>Beta hemolytic streptococcus $/m^3$</th>
<th>Fungi $/m^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Air in the production halls</td>
<td>600</td>
<td>16</td>
<td>300</td>
</tr>
</tbody>
</table>

In the case of bacteria if after 24 hours there is no development of specific colonies on the Petri dishes, they are stored in the thermostat for another 24 hours and the results are expressed after those 48 hours. In the case of fungi, the dishes are stored in optimal temperature conditions up to 5 days. The concentration of germs/m$^3$ of air is determined applying Omelianski's formula. [1]
before the sanitation process, when it was assumed the microbiological load reached maximum. The obtained results are registered in Table 4 for the production hall and in Table 5 for the packaging hall. For each parameter two Petri dishes were always seeded.

### Table 4

<table>
<thead>
<tr>
<th>Luna</th>
<th>UFC/m³</th>
<th>TC/m³</th>
<th>SCP/m³</th>
<th>SF/m³</th>
<th>BHS/m³</th>
<th>F/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1100</td>
<td>18</td>
<td>55</td>
<td>35</td>
<td>0</td>
<td>630</td>
</tr>
<tr>
<td>February</td>
<td>1200</td>
<td>18</td>
<td>58</td>
<td>36</td>
<td>0</td>
<td>600</td>
</tr>
<tr>
<td>March</td>
<td>1200</td>
<td>22</td>
<td>76</td>
<td>43</td>
<td>0</td>
<td>740</td>
</tr>
<tr>
<td>April</td>
<td>2000</td>
<td>31</td>
<td>82</td>
<td>40</td>
<td>0</td>
<td>1100</td>
</tr>
<tr>
<td>May</td>
<td>2300</td>
<td>44</td>
<td>120</td>
<td>44</td>
<td>3</td>
<td>3600</td>
</tr>
<tr>
<td>June</td>
<td>2600</td>
<td>51</td>
<td>180</td>
<td>34</td>
<td>0</td>
<td>4300</td>
</tr>
<tr>
<td>July</td>
<td>2600</td>
<td>79</td>
<td>200</td>
<td>78</td>
<td>8</td>
<td>5200</td>
</tr>
<tr>
<td>August</td>
<td>2500</td>
<td>93</td>
<td>240</td>
<td>94</td>
<td>8</td>
<td>4800</td>
</tr>
<tr>
<td>September</td>
<td>2100</td>
<td>30</td>
<td>340</td>
<td>86</td>
<td>6</td>
<td>3700</td>
</tr>
<tr>
<td>October</td>
<td>2000</td>
<td>25</td>
<td>210</td>
<td>60</td>
<td>8</td>
<td>1500</td>
</tr>
<tr>
<td>November</td>
<td>1600</td>
<td>20</td>
<td>130</td>
<td>60</td>
<td>5</td>
<td>1300</td>
</tr>
<tr>
<td>December</td>
<td>1300</td>
<td>18</td>
<td>90</td>
<td>40</td>
<td>0</td>
<td>1100</td>
</tr>
</tbody>
</table>

### Table 5

<table>
<thead>
<tr>
<th>Luna</th>
<th>UFC/m³</th>
<th>TC/m³</th>
<th>SCP/m³</th>
<th>SF/m³</th>
<th>BHS/m³</th>
<th>F/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>380</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>520</td>
</tr>
<tr>
<td>February</td>
<td>350</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>510</td>
</tr>
<tr>
<td>March</td>
<td>460</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>680</td>
</tr>
<tr>
<td>April</td>
<td>480</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>680</td>
</tr>
<tr>
<td>May</td>
<td>810</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1100</td>
</tr>
<tr>
<td>June</td>
<td>1000</td>
<td>0</td>
<td>26</td>
<td>0</td>
<td>3</td>
<td>1600</td>
</tr>
<tr>
<td>July</td>
<td>1300</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>8</td>
<td>1800</td>
</tr>
<tr>
<td>August</td>
<td>1300</td>
<td>0</td>
<td>36</td>
<td>0</td>
<td>6</td>
<td>1700</td>
</tr>
<tr>
<td>September</td>
<td>1400</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>8</td>
<td>1200</td>
</tr>
<tr>
<td>October</td>
<td>1100</td>
<td>0</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>880</td>
</tr>
<tr>
<td>November</td>
<td>600</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>12</td>
<td>800</td>
</tr>
<tr>
<td>December</td>
<td>420</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>6</td>
<td>600</td>
</tr>
</tbody>
</table>

Analyzing the microbiological indicators, we can observe significantly higher values in the production hall, in comparison with the packaging hall where the packaging of finished products is done. The absence of Total coliforms and Streptococcus faecalis is very relevant – in the packaging room over the whole year and in the period January – May, the absence of Staphylococcus coagulase positive and beta hemolytic streptococcus. From the data in Table 4, the absence of Beta hemolytic streptococcus in the interval between January and April in the production hall as well stands out.

The comparative evaluation of the analyzed parameters in the two halls, shows a similar dynamic of the values, an increase in the summer months, which can be explained with the increase of temperature and implicitly of humidity in the working spaces, especially in the production hall. Physical factors influence the luxuriant development of fungi in this period in the production hall.

Comparing the values obtained with the legislation data it is observed that in the production hall the microbiological load is always above the allowed maximum limit by the legislation. In the packaging hall, in the period January-April, respectively November-December, the CFU parameter was in between the allowed limits. Also, the microbiological load of the atmosphere in the months January, February and December had values that were situated in between the allowed legislation limits, and the beta hemolytic streptococcus parameter over the whole year had values that were allowed by regulations in both halls. It is observed as well that in the packaging hall the indicators of fecal contamination of the atmosphere are absent, they have semnificative values in the production hall. This contamination can originate from the particles of water which end up in the air after the washing process of the timber, utilised as a raw material, from the dust situated on the surface of the timber, but also from the used water discharge
channels situated in the production hall. Although the channels are covered, they are not fully closed and they can consist in contamination sources of the air in of the premises. The fungi contamination of the air in the production hall originates from the raw material, timber which is contaminated. This is why it suffers a series of decontamination processes until the obtainment of the final product.

**Conclusions**

As a result of the fact that the atmosphere, in the premises destined for the production of food or products that come in direct contact with food, presents a varied microbiological spectrum, would require legislation adjustment and the addition of new parameters. The aeromicroflora is directly correlated with the high temperature and increased humidity in the production premises. An increased concentration of the aeromicroflora has been noted in the production and packing premises during the period May to September of 2013. The indicators of fecal contamination and coagulase-positive staphylococci have significant values in the atmosphere of the production hall, at the end of a work week, reason for which some caution measures have been taken:
- the installation of UV radiation lamps at the end of the work program;
- the subdivision of the production hall, so that the contaminated air circulation would be limited to the entire hall;
- the permanent disinfection of the waste water discharge channel, so that they no longer act as sources of contamination.

**References**